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# MEETing the transport materials challenges

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Transportation of people and of freight accounts for a quarter of the world energy demand and for over 60% of all the oil used each year (REF: Source: International Energy Agency. World Oil Energy Consumption by Sector, 1973-2010). One of the greatest drivers for improving energy efficiency is the increasing cost of fossil fuels and a need to reduce emission of harmful pollutants and greenhouse gases.

The optimisation of advanced materials for the manufacture of functional and structural components of road vehicles, aircraft and marinecraft can lead to important improvements in structural weight reduction, reduced energy consumption, lower waste and reduced emissions associated with the transportation of people and goods. New materials can also enable alternative power sources to be employed more efficiently so that we can all stay mobile beyond the lifetime of fossil fuels.

The provision of energy efficient transport is a complicated and multi-faceted problem that encompasses the need to improve the fuel efficiency of existing vehicles as well as the development of infrastructure and supply chains for greater penetration of newly available alternative energy sources.

To address the issues associated with the development of new materials that are capable of delivering the necessary improvements in transport efficiency, the European Union, through the Interreg IV Programme (ERDF), have initiated a three-year research-based UK-French network on Materials for Energy Efficient Transport (MEET).

The MEET Network, which is funded from September 2012 to August 2015, involves a geographical grouping of universities and research centres interested in a wide range of aspects of efficiency in transport. In view of the multidisciplinary themes of the transport sector such as lightweight materials and structures, smart systems, supply chains and new energy sources, the MEET network includes a diverse range of chemists, engineers, social scientists and scientific communicators. The French project partners are CRNS and ENSICAEN at the University of Caen, Institut de plasturgie d'Alençon (ISPA) and Université de Bretagne Sud, while the Universities of Exeter, Bath and Southampton represent the UK.

The project will facilitate greater collaboration and the sharing of expertise, with the support of several market research studies led by innovation development companies such as MIRADE and Mov'eo in France, and TWI in the UK who aim to define the technical and skills requirements in specific transport-related industries.

Some of the research themes of the consortium include:

**Lightweight composites and bio-derived composites** as structural materials for aerospace and automotive industries. The use of fibre based composites is an established technology in the development of materials for aircraft, as the combination of high strength and stiffness with a low density can reduce weight. In addition to mechanical properties researchers are considering imparting functional properties into the composites. For example, consortium members from ISPA in France are now

developing composite materials based on glass fibres that not only enhance the strength and reduce the weight of structural components in vehicles, but can also be used to diagnose the failure points of materials used under stress. The use of bio-derived composites also provides opportunities for a sustainable supply and reduced energy consumption in relation to materials manufacture.

**Advanced materials for on-board energy storage.** On-board storage of the energy generated from intermittent renewable sources is vital for the practical implementation of renewable energies in transportation, be it for road vehicles, aircraft or marinecraft. One method of converting renewable energy into a transport fuel is via the electrolytic generation of hydrogen from water. This hydrogen can then be stored, for example via physical adsorption onto porous materials such as zeolites, high-surface area activated carbons or metal-organic framework materials. These materials act as molecular sponges, adsorbing the hydrogen and storing it at high densities. Comprehensive screening of promising new porous materials for hydrogen storage is being carried out using a combination of experimental hydrogen capacity measurements, modelling and simulation. New models for the comparison of the storage capacities of existing materials with conventional methods of storing fuels (for example, in compressed gas tanks) allow the cost and safety of new systems to be compared to existing methods. In addition, atomistic simulations of the interactions of gas molecules, such as hydrogen and carbon dioxide, with porous materials aids in determining the appropriate structural and chemical qualities for high performance gas storage materials. This new information results in steady improvements in the design

and evaluation of new porous storage materials.

A second option for on-board use of renewable energy is to store it electrochemically, for example, using Li-ion batteries which have recently attracted media interest due to their use in electric vehicles such as the Nissan Leaf. These batteries are already in common use in consumer electronics and thus could be integrated into existing vehicles. However, the need to improve power to weight ratios, cyclability, safety and recharging times require the development of new lithium cathode and anode materials. Such materials, including  $\text{LiFePO}_4$ ,  $\text{Li}_2\text{FeSiO}_4$  and  $\text{LiVO}_2$  are being designed and tested with the aid of computational modelling and simulation.

**Energy harvesting materials** such as thermoelectrics and piezoelectric materials can be incorporated into the structures of vehicles for harvesting temperature gradients or vibrational energy recovery respectively. These materials have the potential to recycle and regenerate energy which would otherwise be wasted.

For example, new materials are being examined for their thermoelectric properties, for harnessing electrical energy from hot regions of vehicles by researchers at CRNT, France and car manufacturers across Europe. For these materials there is a need to maximise the performance at the application temperature and consider the cost implications. Piezoelectric fibres with high activity approaching bulk materials are now commercially available; these have the potential to be incorporated into structural composites, although appropriate methods of integration into host structures need to be developed. In addition to harvesting mechanical vibrations these piezoelectric materials can also offer the opportunity for

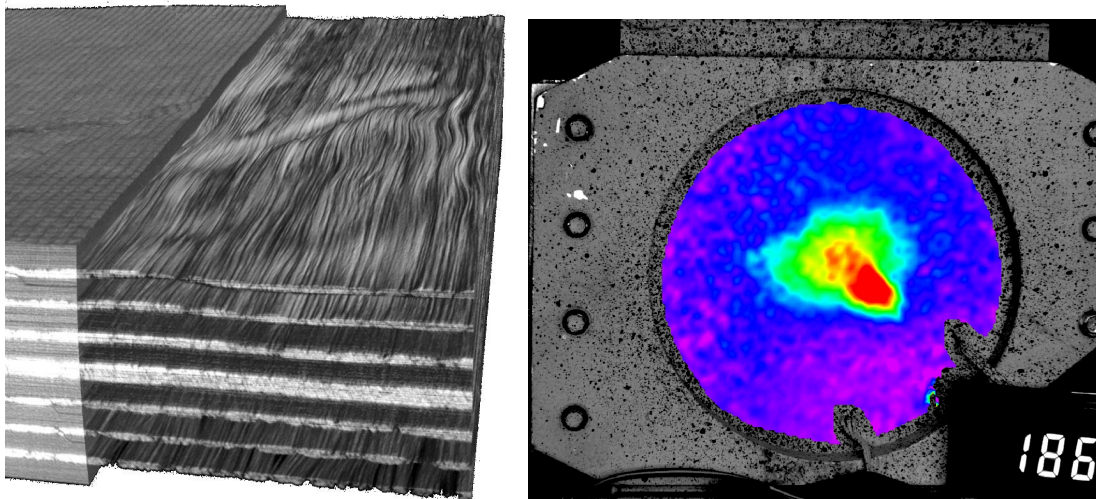
vibration damping. Researchers at the University of Bath and Exeter are investigating the optimisation of vibration damping structures for reduction of the energy loss through extraneous vibrations.

**Porous materials** such as zeolites and metal-organic frameworks are currently used in commercial vehicles in catalytic converters, but they could find additional use as highly selective sensors for monitoring the composition of exhaust gases and thus providing information to the on-board computer for optimisation of fuel consumption. Modification of the atomic structures of these materials can also improve their ability to absorb greenhouse gases such as carbon dioxide, removing them from exhaust streams. These materials therefore have opportunities for multi-functional structures in transport applications.

**OLED/LED materials and devices** will also be examined as they require less energy to operate than traditional incandescent lighting and can be used to lower the weight of instrumentation, personal lighting on aircraft, as well as in motor vehicles.

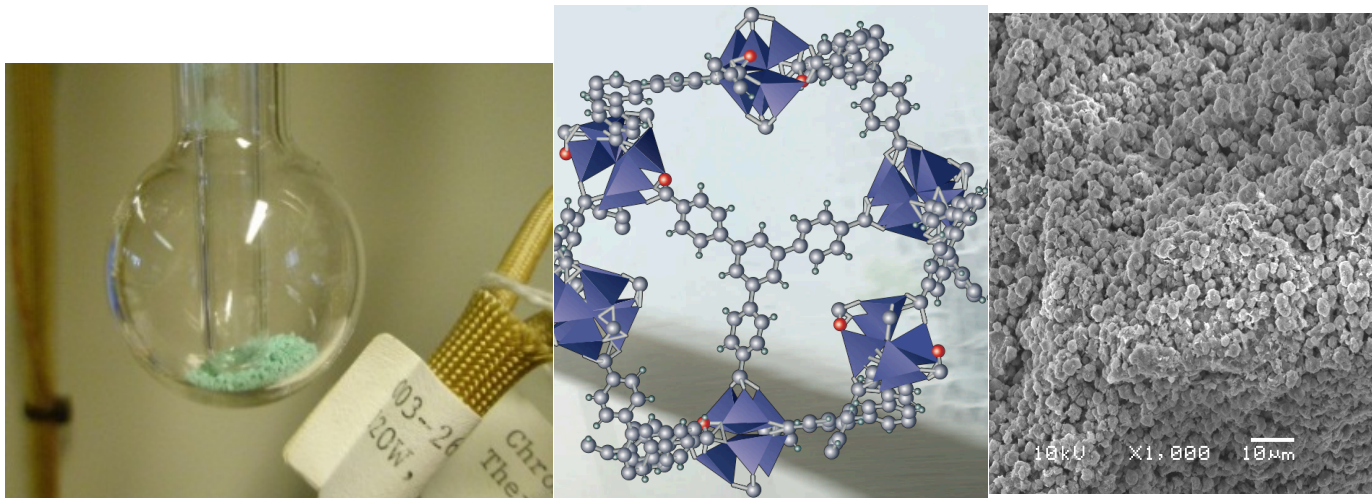
In summary, there are growing demands for improved and multifunctional materials in transport. The MEET network will explore new materials by building partnerships between key players and fostering cross-border research between centers of excellence and encouraging synergies of skills. It also aims to raise interest in materials sciences for energy efficiency in transport and form new collaborations and service supply between laboratories and industries.

### *Images: composites*



*New lightweight composites such as these carbon fibre-based materials can incorporate higher durability with reduced structural weight compared to conventional materials*

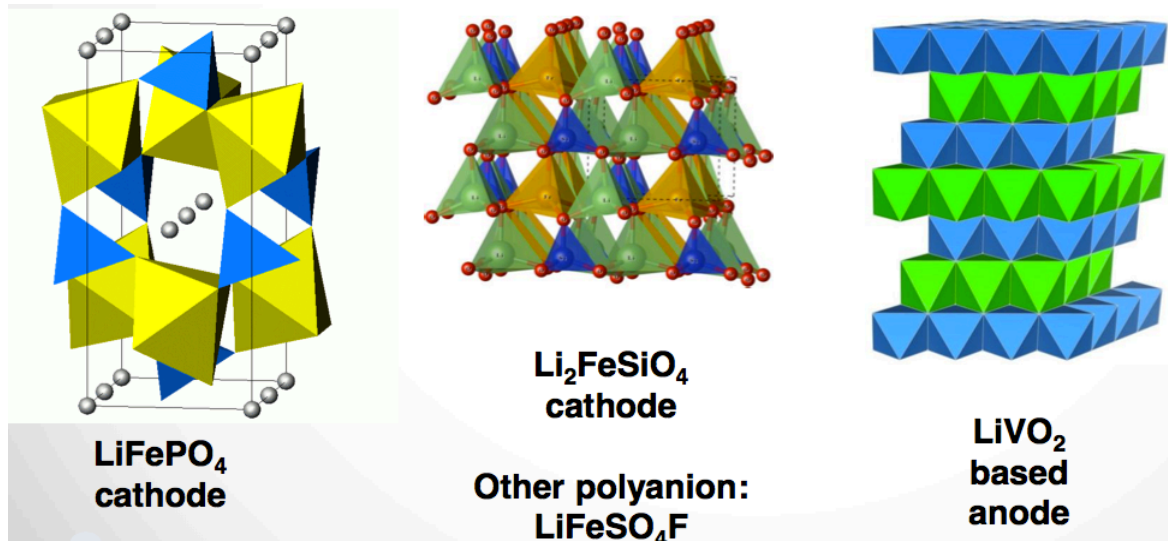
### *Energy storage*



*Design and modification of porous metal-organic frameworks can enhance their capacity for storage of gaseous fuels such as hydrogen or their selectivity for emissions such as carbon dioxide*



### Batteries



*Molecular simulation can aid in the bottom-up design of improved battery materials*

### Smart composites

